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NASA ADVISORY COUNCIL

Human Exploration and Operations Committee

July 29-30, 2013

NASA Headquarters
Washington, DC

MEETING MINUTES

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Richard Kohrs, Chair

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Bette Siegel, Executive Secretary

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HUMAN EXPLORATION AND OPERATIONS COMMITTEE
NASA Headquarters
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PUBLIC MEETING
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Monday, July 29

Opening Remarks

The NASA Advisory Council (NAC) Human Exploration and Operations (HEO) Committee meeting was convened by Dr. Bette Siegel, Executive Secretary. Dr. Siegel noted that this was a Federal Advisory Committee Act (FACA) meeting and open to the public. Minutes will be published. Dr. Siegel introduced Mr. Richard Kohrs, the HEO Committee Chair, who welcomed everyone to the meeting.

Status of Human Exploration and Operations

Mr. William Gerstenmaier, Associate Administrator for the Human Exploration and Operations Mission Directorate (HEOMD) at NASA Headquarters (HQ), provided an update on the status of Human Exploration and Operations. He showed the International Space Station (ISS) flight plan through April 2015. The Automated Transfer Vehicle (ATV) 4 is on orbit now; the H-II Transfer Vehicle (HTV) 4 will be launching on August 9. The Cygnus demonstration flight to ISS is scheduled for September 14, but it will probably launch on September 17. Progress 52P docked at the ISS last night. Soyuz 36S and 37S will go to the Station in September and November. At the macro level, this is a very busy time on ISS, and research is moving forward. There will be three Soyuz docked at the ISS in the December timeframe.

The Soyuz 35 crew and the Expedition 36 crew are on orbit. Utilization is doing very well, despite the heavy vehicle traffic. The Program is now able to have one crewmember doing an investigation in one module and another crewmember doing an investigation in a different module; the Principal Investigators (PIs) can talk to the crew. Mr. Gerstenmaier reviewed the Increment 35/36 crew time for utilization. Through Increment week 17, the total U.S. Orbiting Segment (USOS) average utilization hours per week was 41.3, which is above the 35 hours per week target. There are over 200 investigations in Expedition 35/36. Overall, over 400 investigations have been represented since ISS utilization started.

Mr. Gerstenmaier reviewed the status of the Center for the Advancement of Science in Space (CASIS). CASIS is beginning commercial partnerships with Boston Museum of Science, MD Anderson, Baylor College of Medicine, Massachusetts Institute of Technology, MassChallenge, Boeing, and others. They are reaching out to commercial providers and showing them the benefits of spaceflight. CASIS has been stimulating interest from outside the traditional space community. CASIS also has Memoranda of Agreement with other government agencies such as the National Institutes of Health (NIH), the National Oceanographic and Atmospheric Administration (NOAA), the U.S. Department of Agriculture (USDA), the Veterans Administration (VA), the Department of Defense (DoD), and the Naval Research Laboratory (NRL).

In response to a question from Mr. Kohrs, Mr. Gerstenmaier stated that user experiments are still going through the safety process; however, they have been able to reduce the integration time. There is a unique ability to add items late in the integration process, and this has been very useful for student investigations, which can go up and back in as little as five months.

The Advanced Exploration Systems (AES) group looks at rapid development and testing of prototype systems and validation of operational concepts to reduce risk and cost of future exploration missions. Mr. Gerstenmaier cited some recent accomplishments. The ISS is an excellent testbed for prototype systems. AES is working on the Morpheus lander, a new landing system that will provide a generic, autonomous precision landing capability. The AES group also helps with the Goldstone radar, which has imaged over 10 candidate targets for crewed near-Earth asteroid (NEA) missions. The Radiation Assessment Detector (RAD) will be very useful in assessing the radiation on Mars. AES is partnering with the Science Mission Directorate (SMD) and the Space Technology Mission Directorate (STMD) to develop an in-situ resource utilization payload to demonstrate oxygen production from the Martian atmosphere.

Mr. Gerstenmaier showed the summary schedule for Exploration System Development (ESD). The Space Launch System (SLS) booster Preliminary Design Review (PDR) is being completed in Huntsville. Overall, it has been a successful review. Mr. Gerstenmaier indicated that he was very encouraged, and the Program is moving along well.

Orion is getting ready for Exploration Flight Test (EFT)-1 in September 2014, and the program is still on track. The heat shields are currently undergoing fabrication. There is a considerable amount of activity at the Kennedy Space Center (KSC). The EFT-1 crew module has gone through the static loads test. During the fairing separation test at Lockheed, one of the panels failed to deploy and a redesign is in process that will resolve the issue. There have been several recent parachute tests at the Army Yuma proving ground in Arizona. One of the recent tests deliberately failed one of the parachutes to test the margins. Everything went extremely well. In response to a question, Mr. Gerstenmaier indicated that the avionics on Orion will be active on Exploration Module (EM)-1; however, the Environmental Control and Life Support System (ECLSS) will not be active until EM-2.

With regard to the SLS core stage, the vertical weld was completed on the first trial barrel segment. One machine does this vertical weld, and it is an automated process. The program is able to get results from the weld immediately. The Vertical Assembly Center (VAC) is being put in place at the Michoud Assembly Facility (MAF). Other elements are being assembled at the Marshal Space Flight Center (MSFC). The center segment for Qualification Motor-1 (QM-1) has been delivered to its test bay at Alliant Techsystems (ATK) in Utah. In response to a question, Mr. Gerstenmaier stated that NASA does not plan to recover the boosters.

NASA is currently participating in landing and recovery activities for the Ground Systems Development and Operations (GSDO). The Crew Module Recovery Cradle testing was completed at Langley Research Center (LaRC). Facility modifications are underway in the Multi-Payload Processing Facility (MPPF) and the Pad B flame trench is under demolition and rebuild.

Mr. Gerstenmaier highlighted some recent accomplishments in Space Communications and Navigation (SCaN). All of the mission images and data come through the communications system, which consists of the Deep Space Network (DSN), the Near Earth Network (NEN), and the Space Network (SN). NASA has been installing 34m antennas at the DSN site in Canberra. This is an effort to replace the 70m antenna with an equivalent aperture array of smaller size antennas. Factory acceptance testing has been completed for the new 11m antenna in Alaska, which is critical to meeting the growing Earth science requirements. HEOMD is in the process upgrading the SN at the White Sands Complex to a digital installation, which will fit in with the rest of the communication networks. Mr. Gerstenmaier noted that most of the Tracking and Data Relay Satellite System (TDRSS) data comes through White Sands. A new satellite (TDRS-K) is on orbit and currently going through on-orbit testing. TRDS-L is scheduled for launch in January 2014. TDRS-M completed its Production Readiness Review (PRR) and will be ready for launch in early FY 2016.

The SCaN Testbed (STB) was launched to the ISS in August 2013, and its commissioning has been completed with all operations nominal. It can program waveform and will allow changing the waveform on the fly. This experimental program is well underway, and it has many applications in the future. STB is a great example of how the ISS can provide for experimental testbeds in a low-risk environment. In response to a question, Mr. Gerstenmaier noted that this equipment was built predominantly by the Glenn Research Center (GRC) and was launched on an HTV about a year ago. STB has many non-NASA users and has generated much more interest than anticipated.

HEOMD's next major payload to be launched is the Lunar Laser Communications Demonstration (LLCD) onboard the Lunar Atmosphere and Dust Environment Explorer (LADEE) to the Moon on September 6. The LLCD is critical to validate optical communications technology for future space communications. The primary ground site for the LLCD is at White Sands. The LLCD uses photon counting rather than beam shifting for optical communications.

SCaN participated in the InterOperability Plenary (IOP)-3 held in France last month. This activity is important because international standards are being set and this is the precursor work for the future. Optical frequencies and interoperability are being examined and considered. If the right standards are set at the beginning, interoperability will be available in the future. The SCaN group also does all the spectrum management for the Agency. It works on the international level to ensure that bands are protected for science missions. With regard to Global Positioning System (GPS) policy, SCaN works heavily with the interagency GPS committee.

NASA's Space Life and Physical Sciences Research and Applications (SLPSRA) Division has been formulated to execute high quality, high-value research and applications activities in the areas of fundamental space biology, physical sciences, and human research. The Division will use the ISS to develop the Open Source concept within the Agency, other government organizations,

and research communities. This helps open the NASA data sets to the broader science community and is a promising way to get more results from the ISS laboratory.

Mr. Gerstenmaier noted some other research accomplishments. In addition to tracking the number of publications from ISS research, they are also tracking the number of times such publications are cited by other sources. This shows the importance of the ISS papers and results. In response to a question, Mr. Gerstenmaier explained that MSFC does the fundamental or basic research; CASIS's focus is more toward applied research, but there is communication between the two. The SLPSRA Division has also participated in Bion-M1 experiments with the Russians. A new phenomenon on "cool-flame" burning was discovered and may have real-world applications in the fire suppression arena. On the plant side, there has been a lot of interest in flying plants and understanding how plants grow in space. This has potential applications to food source augmentation. In the Human Research Program (HRP), ISS research results have demonstrated the effectiveness of exercise using the ISS Advanced Resistance Exercise (ARED) device and drugs in significantly limiting bone loss in crew; however, the actual bone structure may be changing, and the HRP is looking at new devices to measure bone interior.

Mr. Gerstenmaier briefly updated the Committee on commercial cargo and crew. SpaceX has commenced regular Commercial Resupply Service (CRS) flights to the ISS. Orbital Sciences has its demonstration flight in September as soon as the LADEE mission launches. If Orbital's flight is successful, its first cargo flight can go in December. SpaceX is also scheduled to fly again in the December timeframe.

With regard to commercial crew, all three partners are completing their milestones under the Commercial Crew IntegratedCapability (CCiCAP) agreements, and they have begun certification work under the Certification Products Contracts (CPCs). Mr. Gerstenmaier noted that Mr. Phil McAlister would discuss this topic in greater detail later in the meeting. The program is on track to deliver a certified capability by 2017, depending on budget and technical progress.

Mr. Gerstenmaier provided an overview on the Launch Services Program (LSP). The primary purpose of the LSP is to acquire launch services and perform verification and validation to meet the certification plan. The LSP started flights in October 2011. Since then, there have been a total of seven flights. The next flight is the Mars Atmosphere and Volatile EvolutioN (MAVEN) mission in November 2013 on an Atlas V. LSP is also providing advisory support to LADEE. Mr. Gerstenmaier showed the Launch Services Task Order (LSTO) schedule through 2016. Even though flights are far out in future, there is a lot of work that needs to be done in advance, such as selecting the contractor and the integration activity. Much more is involved than just launch readiness.

Mr. Gerstenmaier provided a brief overview of the current launch vehicle situation. There is currently only one "certified" launch vehicle (Atlas V) in the intermediate class, but 2 more viable competitors are expected. All medium-class missions between FY14 and FY17 have been awarded with launch services. For FY18 and beyond, Falcon 9 and Antares are expected to replace the Delta II. There are currently two certified launch vehicles (Pegasus XL and Taurus XL) for small-class missions. New providers are developing dedicated launch vehicles for the "nano-sat" market.

Mr. Joseph Cuzzupoli asked Mr. Gerstenmaier for his opinion on the morale situation at the NASA Centers, given the current economic stability. Mr. Gerstenmaier indicated that morale is fairly positive. At MAF, the workforce is very excited about building the next set of hardware. At MSFC, things are also good; the program went through the PDR with few items going to the Board. With the next generation rocket, the workforce has a sense of future. Johnson Space Center (JSC) is on track with Orion and some of the research is coming in. Considering the overall environment, the Centers are still excited. Mr. Gerstenmaier suggested that the HEO Committee go to field Centers and look at what they are doing. In response to a question, Mr. Gerstenmaier reported that he has had "all hands" meetings at MAF and MSFC, but has not had one recently at JSC.

There were several questions about ISS. With respect to maintenance and operations, the failure rates have been low overall and less than expected. They are in the lower part of the maintenance curve with results better than anticipated. Micrometeoroid and Orbital Debris (MMOD) is still a major risk and the Station is being monitored closely. An external survey was just recently completed. There have been quite a few "hits" to the solar panels. The crews do inspections while on fly-arounds as well as dedicated inspections. So far, they have not seen anything that concerns them. As the program pushes to the 2020 timeframe, the solar arrays will be one component that will degrade and will need to be changed out. However, there is nothing that is causing undo alarm. Payloads are good from a power standpoint.

Dr. Leroy Chiao asked about the mood going though 2028. Mr. Gerstenmaier stated that the U.S. will have to take the lead on that. The partners are still looking for demonstrable return on investment (ROI). They have not pursued some things the U.S. is

doing; for example, with transportation and CASIS. They are not quite seeing the ROI yet. On the other hand, a lot is being learned about intracranial pressure. Overall, the U.S. is seeing stronger benefits from the Station than the partners are.

Status of Exploration Systems Development (ESD)
Mr. Daniel Dumbacher provided a summary overview of ESD status and schedule and an update on the SLS PDR, the MAF, EFT-1, and the European Space Agency (ESA) service module. He showed a video of the recent fairing separation test.

Orion events have been progressing. After the crack repair, the EFT-1 crew module successfully completed all loads testing. The backshell panel for EFT-1 is in drilling. As noted earlier by Mr. Gerstenmaier, the parachute assembly was deliberately failed and the capsule landed safely. The heat shield is in work at Textron. The service module panels have been completed and delivered to KSC. During the fairing separation test at Lockheed Martin in Sunnyvale, one of the fairing panels hung up. There was an error in the hardware configuration, and the model is being updated. The ECLSS work is proceeding well. Crew module reaction control system (RCS) testing is ongoing at Aerojet. Orion is making good progress on all fronts, and the program is on track for the September 2014 launch. Currently, there are about 75 days schedule margin. Progress on the heat shield, which had been a major risk item, is going well.

Mr. Dumbacher highlighted recent SLS accomplishments. At MAF, the VAC is being constructed for the core stage production. This will be largest friction stir weld tool in the world. The Multi-Purpose Crew Vehicle (MPCV) stage adapter welding for B1 is finished at MSFC. Work is continuing on B2 (the core stage with 4 engines). So far, the project is running slightly under budget. In response to a question, Mr. Dumbacher stated that the core stage test is a 400-500 second burn. The program has completed some ground level testing on the gas generator for the F-1 engine. This is a technology demonstration for the advanced booster concept. Wind tunnel work continues at LaRC. Engineers have been meeting with Dryden Flight Research Center (DFRC) personnel about the planned flight test of the Adaptive Augmenting Control on an F-18. All of the J-2X testing has been going very well. The controller for RS-25 will be the one of the primary things that will come out of testing. The controller is built by Honeywell, but Aerojet/Rocketdyne is responsible for the hardware. Ascent control for SLS is being tested on the F-18 to get flight profile data. Mr. Cuzzupoli advised NASA to make sure all of the responsibility is under one house.

Mr. Bohdan Bejmuk raised a question about booster recovery. In response, Mr. Dumbacher indicated that the program has been through the analysis on whether or not to recover the booster. Based on the hardware performance and the level of inspections, they believe that the process controls are sufficient to have an expendable booster. This has enabled the program to be able to eliminate costs associated with recovery systems.

Mr. Dumbacher reviewed recent activities associated with the GSDO. At KSC, the Pad B flame trench is being “redone” for the first time since Apollo. They are getting ready for the crew module landing and recovery. EFT-1 will also provide practice with the recovery system in the Pacific. Display systems are coming up to speed at KSC. Pad 39B has been cleared of all Shuttle hardware and is proceeding well for the SLS 2017 flight. Roller bearings are being replaced on the crawler.

In response to a question from Mr. Kohrs regarding multi-payload processing, Mr. Dumbacher indicated that the MPPF is not a new facility, but it is undergoing modifications to enable hazardous processing. It will be where Orion is fueled.

In response to a question from Mr. Bejmuk, Mr. Dumbacher indicated that they have launch probability numbers, and those numbers are being used as a driver to the design process and the environment assessment process. The goal is to do better than Shuttle. Day-of-launch I loads will be utilized. Test, and Launch Operations (ATLOs) are being used.

Mr. Dumbacher showed the current HEO/ESD schedule out to EM-1. They are on schedule and expect to imminently complete the PDR milestone for SLS. Currently, there are no significant issues. They are in the detail design process for the core stage. Orion is working toward EFT-1. GSDO has started its element level PDRs. EFT-1 is using the Delta IV heavy and standard upper stage. For EM-1, the hydrogen tank on the upper stage is being “stretched” by 18 inches to obtain some extra performance margin. The mixture requirements are not being changed. In response to a question, Mr. Dumbacher explained that if the stretch is done now, the extra performance capability could be done for considerably less cost than later in the timeline. The simple solution was to add 18 inches to the H2 tank and do nothing else before the structural build. This adds performance margin at a low cost. The exact amount of margin depends on the mission. The EM-1 mission (distant retrograde orbit in the lunar system) has plenty of margin; in fact, they are looking at secondary payloads. EM-2 is using the Interim Cryogenic Propulsion System (ICPS). EM-3 will be subject to trade studies on advanced boosters and upper stage. The program had already planned on making changes for EM-3. That decision will be made in 2016. The biggest effect of a slip on EFT-1 would be on the Orion design. However, the launch vehicle is on track and looking good for 2014.

In response to a question regarding the degree of tank extension, Mr. Dumbacher stated that an 18 inch extension would allow them to stay within the mixture ratio that had already been certified. For the asteroid mission, Mr. Dumbacher explained the reason why launch probability was established as driver for design. For missions that depend on orbital mechanics, launch probability is very important. The Asteroid Redirect Mission (ARM) would be EM-2. The program is using the launch probability requirement as a design driver to maximize the probability of launching on time. They still need to work through the risk assessment to decide on the right asteroid mission for the crew.

Mr. Dumbacher noted that the SLS PDR Board meeting would be tomorrow. By all accounts, there should be a successful PDR. The SLS PDR is being held to the 7120 and 7123 requirements. In response to a question from Mr. Cuzzupoli, Mr. Dumbacher noted that the longest item on the PDR is probably loads, but the program has a good handle on those and the team has an excellent approach. It is a matter of getting through all the work and synced up with Orion. However, all of the work is going per plan and they are on schedule for getting the loads cycle complete.

Mr. Dumbacher showed the layout of the MAF and where the Vertical Weld Center (VWC) is located. He also showed pictures of the tooling going into each of the areas. Except for the VWC, all the tooling is in place. By end of the year, they will have run at least one major weld for each of the pieces. In response to a question, Mr. Dumbacher noted that Ares 5 was going to be 33 feet in diameter, and NASA was developing tooling to handle up to 33 ft. The tooling being developed for Ares 5 also had application for 27.5 ft. The tooling and expertise transferred to MAF, and they are running pathfinders through it. The VWC will weld barrel panels together to produce whole barrels for SLS core stage. On a recent MAF visit, he went to Stennis Space Center (SSC) to take a look at the B2 test stand for core stage testing. SSC is doing a good job.

Mr. Bejmuk raised a question on loads. He observed that it appears that they have changed the way loads are taken on this core stage versus the way it was done on Shuttle. Mr. Dumbacher replied that the trade study showed that this change better enabled an advanced booster later downstream. The difference in loads has been factored into the design and there have been structural test to verify the loads.

Mr. Dumbacher provided a status update on EFT-1. Parachute Entry, Descent, and Landing (EDL) is ongoing. All testing has been successful to date. All of the parachute data is going to the commercial crew partners, and they are using this data in their design process. The Committee viewed a video of the heat shield at Textron. It has a 16.5 diameter—the largest heat shield of this diameter ever built. The project planned for a 0.7 percent reject rate; they are running at 0.3 percent. They have done a very good job in preparing the tooling and the processes. The heat shield will be delivered to KSC early this fall. In response to a query, Mr. Dumbacher stated that the heat shield material is Avcoat, which was used on Apollo. Some modifications have been made to comply with current EPA regulations. If a flaw is detected, the cell has to be dug out and repoured.

Mr. Dumbacher showed the setup for the jettison test at Sunnyvale, and the Committee viewed a video of the fairing separation. During the test, one panel did not separate. The team was off on some of the analysis. Based on this test, they know what they need to do to fix it. In response to a question from Mr. Cuzzupoli regarding a similar problem on an Orbital vehicle fairing, Mr. Dumbacher indicated that he didn't think this was the same type of problem, but he would have to check. On EFT-1, the escape system is a "dummy," but the jettison motor will be exercised. EFT-1 is important for design.

Across the board, personnel at all Centers and suppliers (such as Textron), are motivated and working long hours, as evidenced by the progress the civil service and contractor team is making. They are thoroughly professional and are doing an excellent job. The reject rate is half of what was expected and planned for. Mr. Dumbacher encouraged the HEO Committee to visit the Centers. Morale and motivation is high, and issues are being proactively worked.

Mr. Bejmuk expressed concern about loads and the joints between segments. This design will put the joint in tension rather than compression. This was a significant issue on Shuttle, and he indicated that he was surprised that the safety people were not more concerned. Mr. Dumbacher emphasized that the technical team and Safety and Mission Assurance (SMA) work together; they have been part and party to all decisions. Data from the Shuttle and the data from qualification motors have led to the decision to not recover the booster system. With all of the technical expertise that has been involved (including Shuttle), they feel that they have made the right decision. Mr. Dumbacher took an action to get the data on loads to Mr. Bejmuk.

Status of International Space Station

Mr. Sam Scimemi, Director of the ISS, HEOMD at NASA HQ, briefly reviewed the ISS program status. He highlighted a few expedition events. Crew Utilization time is running slightly better than plan (40 hours per week versus the plan of 35). Most of the

crew time is consumed by "keep alive" work—sleeping, eating, exercise, and Station maintenance and operation. ISS is doing very well on consumables.

Mr. Scimemi discussed several recent USOS challenges. In May, the crew discovered a leak in the Photovoltaic Thermal Control Systems (PVTCS). The crew performed an extravehicular activity (EVA) repair/replace with a spare unit and they have not seen any problems since. The failure cause was identified—too much lubricant on the latch—and the remaining latch was refabricated. Remaining latches now have a different mechanism. During the 51P orbit, one of the Kurs-A antenna units failed to deploy, and there was risk of potential damage to the ATV retro-reflector. Analysis was performed and a plan was developed to dock Progress in the stowed configuration. Progress 51P was successfully docked and there was no damage. After Progress undocked from the ISS, the antenna fully deployed. Recently, there was a Ku band antenna group 2 failure; the Ku-band was swapped to antenna group 1. In response to a question, Mr. Scimemi stated that the U.S. is responsible for anything that affects the safety of the entire Station.

Last year HTV-3 aborted. The abort was caused by an interaction between the grapple fixture cam arms on the vehicle and the initial motion of the Space Station Remote Manipulator System (SSRMS). New procedures have been implemented. NASA has worked closely with the partners on the loading/unloading processes.

The trouble-shooting over the last few days on the EVA 23 EVA Mobility Unit (EMU) internal water leakage has not revealed the problem. NASA is looking at all types of capabilities to mitigate the risk. The check valve was not the issue. The team has run all the fault trees and has not located the cause. The crewmember had about 1 to 1.5 liters in the suit; the coolant level was down 1.8 liters. Mr. Gerstenmaier has kicked off a Mishap Investigation Board (MIB) activity, which starts Friday. It will report out within 75 days.

Mr. Cuzzupoli asked about the Russian booster failures, specifically, if NASA is concerned about this hardware failure. Mr. Scimemi indicated that NASA is not "concerned," but is keeping a close eye on this issue and communicates closely with Russian colleagues. The system that failed is not used in the ISS Soyuz/Progress system. The Russian failures are a quality control issue, not a design issue. NASA has contracted for seats on Soyuz through Spring 2017. Three seats are available on every Soyuz flight; the U.S. always has one or two crew in the crew complement.

In response to a question regarding NASA's position on the Commercial Crew Program (CCP) downselect, Mr. Scimemi noted that NASA is working the safety process with the commercial partners. Overall, the process by which cargo is manifested is agreed to by all partners. Everything must be certified. If the CCP vehicles are not certified by 2017, NASA will reorder more Soyuz capability. Mr. Scimemi confirmed that NASA is well aware of the 36 month leadtime.

Mr. Cuzzupoli commented that Russia has been a good partner. However, if one considers the track record of the past two and a half to three years, they appear to be struggling. He posed the questions: Is there a system-wide problem in Russia? Is NASA concerned about increased reliance? Mr. Scimemi responded that from an ISS perspective, NASA has been doing everything it can to obtain funding to meet the 2017 commercial crew services date. Mr. Cuzzupoli clarified that he was asking the question as a safety concern. Mr. Scimemi agreed that relying solely on Russian elements is a risk. However, the recent issues have all been quality control issues. Russian industry has been going through reorganization. NASA works closely with Russia to understand all the risks.

Mr. Scimemi provided an overview on payload integration. The ISS payload philosophy is to fly and operate a payload as soon as it is ready. There is no longer a "standard template" to which users are forced to adhere. The payload integration team fits them into the process, and there is a lot more flexibility to incorporate users into the system. For example, there is increased ground communication, improved data rates, common lab software on-orbit, expanded laptop operation, and an "internet in space." Mr. Cuzzupoli inquired about air to ground conversations with scientists, specifically, in terms of having a potential mishap. Mr. Scimemi explained that everything is monitored to ensure flight rules are not broken. The Principal Investigator (PI) only talks to the crew on a very defined set of parameters. Appropriate controls are in place.

Strategic research planning is conducted annually by looking forward three years to determine if resources are adequate to meet customer requirements. Increment-specific research planning begins 18 months prior to the mission. The first research plan is 12 months before the mission. In response to a question from Dr. David Longnecker, Mr. Scimemi stated that all of the research equipment components are changeable—not only individual experiments, but an entire box itself, e.g., the entire glovebox. Spares are onboard.

The ISS has well-defined interfaces allowing payload to be designed with minimal risk and ground testing. ISS provides all of the flight support equipment and interface hardware. The ISS laboratory environment allows greater payload design flexibility. Commercial-off-the-shelf equipment is encouraged, e.g., class "D" hardware. Mr. Scimemi emphasized that the equipment still goes through a safety process—the "Class D" classification is related to mission success. These changes have substantially reduced the payload design and integration costs on the payload developer's side. There are only a few payload key milestones: Critical Design Review (CDR), software integration, and training products. If users have already been through the integration process, they can be re-flown very quickly. For pressurized payloads, cargo can be manifested as early as 12 months prior to the mission. For flights today, utilization has a priority. Delivery of cargo to the packing site is driven by the carrier vehicle. For external payloads, the leadtime for HTV launch is 24 months; SpaceX launch is 18 months. Delivery date to the launch site to begin vehicle integration is determined by the carrier—HTV is six months, SpaceX is one month. In response to a question, Mr. Scimemi noted that Cygnus (the Orbital carrier) is designed only for pressurized payloads.

Mr. Scimemi discussed the legacy of the ISS. He recounted some space station history, starting back in 1984 with President Reagan's State of the Union address. The Station has been in orbit since November 1998 with launch of the first element. One of the continuing questions has been: What is the purpose of the ISS? Today, the purpose is four-fold: (1) to advance the benefits to humanity through research; (2) to enable a commercial, demand-driven market in Low-Earth Orbit (LEO); (3) to enable long duration human spaceflight beyond LEO; and (4) to be the basis for international exploration partnerships. Extension of Station beyond 2020 is essential to meet these objectives.

Mr. Scimemi emphasized that research takes time—for example: the time to complete a study in orbit is two weeks to over five years; the time from completion of a study to first publication is one to three years; the time from publication or patent to product in the marketplace can be three to thirty years. These are not NASA numbers; this is the nature of research. There are three primary categories of ISS research: discovery, benefits to humanity, and enabling future exploration. There are ISS resource limitations and costs to use the platform. Mr. Scimemi highlighted two of the recent research activities that have led to medical advances: the NeuroArm, the result of software development between NASA and the Canadians on the use of the robotic arm; and dusty plasma applications for medical applications and neutralizing drug-resistant bacteria. Extension from 2020 to 2028 offers 166 percent more research on ISS for external sites and 85 percent more research for internal experiments. It would provide 103 percent more crew time for research.

Part of the ISS mission is to enable a commercial demand driven market in LEO. Over the next ten years, the Federal Aviation Administration (FAA) predicts that commercial crew and cargo flights to the ISS will account for 57 percent of the non geosynchronous-Earth orbit (GEO) launch market. Without a definitive commitment to extend the ISS beyond 2020, it will be very difficult to have commercial crew development activities. Likewise, CASIS would not have much time to develop the commercial use of ISS. If companies see ISS ending in 2020, they would be unlikely to invest in utilization.

NASA has been doing analysis on how long the Station would last from a technical standpoint. Currently, that is 2028. There are internal policy discussions on where NASA is on the extension policy. NASA has not had serious discussions with the international partners to go beyond 2020. In response to a question, Mr. Scimemi stated that the Russians probably want to go beyond; some of the other partners are more willing than others. NASA must have the human spaceflight discussion with them before they can decide. In response to a question from Dr. Pat Condon on what needs to happen or be decided to extend beyond 2020, Mr. Scimemi indicated that it is policy—NASA, the White House, and Congress. To make it happen, the decision must be made within the next couple years. Discussions are ongoing within NASA, and the Agency would like to get a policy decision this year (during the 2015 budget process). Dr. Longnecker commented that the commercial partners want to know if their investments will have return, and extension to 2028 is an important factor. He indicated that the Committee would be interested in knowing more about the extension discussions. Mr. Scimemi agreed that users want to know whether or not NASA is committed to extension. This has been brought to the Agency's attention by CASIS.

In response to a question, Mr. Scimemi noted that the ISS international treaties do not expire—they are open-ended. This was done deliberately to allow Station to evolve. The Japanese are struggling in a more severe budget environment due to their economy and the tsunami. Europeans have their own traditional issues. The U.S. would like to have all the partners stay through extension, but the essential partner is Russia—the Station couldn't fly without them.

Mr. Scimemi continued with a discussion on how commercial utilization could be achieved. The ISS would need to demonstrate that the fundamental question regarding microgravity can be answered. It would need to create opportunities to address those questions through seed funding, partnerships, grant challenges, and outreach. The research community at large would need to be familiar with the CASIS business model and the utility of the ISS. The user process would need to be streamlined while

preserving the safety and integrity of the crew and the vehicle. Time-to-flight and cost would need to be reduced and repeatability would need to be achieved. Some of the companies that CASIS has flight project agreements with include Proctor and Gamble, Merck, and Cobra Puma. ISS can also enable the demand for commercial uses in LEO that could lead to a commercially-provided platform.

In response to a question about tourism, Mr. Scimemi noted that with commercial crew, additional seats will be available for tourism. NASA is evaluating that now. Mr. Scimemi indicated that he could come back at the next meeting and discuss this topic further.

In response to a question from Mr. Kohrs on what CASIS tells users today regarding timeline, Mr. Scimemi noted that there is not a standard answer. Many factors are involved. Is the payload internal or external? Is crew involved? What is the payload complexity? It can be less than a year. Mr. Kohrs suggested that NASA advertise the ISS capabilities and use examples of how quickly payloads have been put on. For example, a couple of meetings ago, Mr. Gerstenmaier stated that "payloads fly free," but he has not seen any advertisement that says this. Mr. Scimemi noted that CASIS is advertising this, but they are not focused on the general public. Mr. Kohrs asked Dr. Longnecker to take an action for his group to promote this type of outreach.

Dr. Condon asked about the importance of Station in facilitating a trip to Mars. Can a human trip to Mars be achieved without extending the ISS? Mr. Scimemi replied that it most likely could not because the human health research is needed. There is no way to solve all the medical issues without ISS extension. Dr. Condon emphasized that NASA should be "beating the drum" about extending Station. Ms. Nancy Ann Budden suggested making a recommendation to reinvigorate the extension of Station as a waypoint for deep space exploration.

Tuesday, July 30

Dr. Siegel called the meeting to order, noted that this was FACA meeting and open to the public, and that minutes would be published.

Status of CASIS and Research Subcommittee

Dr. Marshall Porterfield, Director of the SLPSRA Division in HEOMD at NASA HQ, discussed the current status of CASIS, development of the NAC Research Subcommittee.

The SLPSRA Division has been formulated to execute research in the areas of space biology, physical sciences, and human research. The primary purpose is to conduct fundamental and applied research to support human space exploration. The Division works with CASIS at the strategic level. In response to a question regarding the relationship between the Division and CASIS, Dr. Porterfield noted that CASIS is chartered to develop and support research that has benefit back on Earth and to increase the utilization of the ISS. CASIS developed research pathways based on a review of ten years of NASA research. There is overlap between the Division's program and CASIS, and there is now better coordination and collaboration between the two.

CASIS was awarded a Cooperative Agreement in August 2011 to develop the capability to implement research and development projects using the ISS. The Agreement has a planned value of $15M per year. CASIS began with an interim Board of Directors; the current Board was appointed in November 2012. Dr. Porterfield noted that he had covered the Board biographies at the last HEO Committee meeting. The Board has continued weekly special meetings throughout the quarter as well as a quarterly meeting. The next scheduled quarterly is in October. During the third quarter, the Board approved and released a new strategic plan. Dr. Porterfield noted that there are some issues related to that strategic plan, and the Division will send its recommendations back to the Board. One of the recommendations is to include more venture capital experience on the Board.

The Board approved the release of the RFP for opportunity for stem cell research on ISS. They also approved a response to the recent Inspector General (IG) report. During the quarterly meeting, there was an opportunity to interact with industry in the Houston area. Major activities focused on the deployment of a business and partnership ecosystem in Houston. It was targeted in the Houston area because of the strong ties to the space program and JSC. The Business Development team continued its work with Boeing to discuss a partnership focused on establishing a Texas innovation accelerator opportunity. Also in the area of business development, CASIS announced that they are in partnership with Novartis Pharmaceuticals to provide proof-of-concept verification science on the initial rodent habitat flight on SpaceX-4. In conjunction with NASA, CASIS has coordinated the validations plans for the hardware and crew time. SpaceX-4 is scheduled for launch later this calendar year.

Within operations, CASIS just completed the ISS Research and Development Conference in Denver, including the Implementation Partner Tradeshow and a New Users' Workshop. The payload development and integration activities for projects scheduled to launch during Increment 37/38 continue on schedule. Dr. Porterfield acknowledged that the volume is low. A number of factors limit the ability to utilize the ISS, and the Division is looking at ways to increase the throughput.

The NAC formed a Research Subcommittee of the HEOC. It held its first meeting in April 2013. The next meeting is July 31, 2013. The Subcommittee will review the relationships between research and technology and between human research and space biology. The main focus now is on implementation of the new science management strategies based on an "open source science" approach. Another area of focus is biomedical models.

One of the key elements with regard to research in the Division and the focus of the Subcommittee will be the response to the National Research Council (NRC) Decadal Survey. It outlined a large number of recommendations. The Division has prioritized the recommendations. The technologies in the Decadal Survey are referred to as bioinformatics—tools that allow the study of the human genome. New technologies allow for study on the output of the genome. Dr. Porterfield explained that we now have the ability to measure all of the different components, sometimes referred to as the Expressome—the expression of the genome in a living system. With the new initiatives, we want to be able to use all the approaches in an experiment. In response to a question, he indicated that this doesn't necessarily have to be done in space. The model being developed could be used on the ground. However, it is very expensive to do all the approaches in one experiment. Dr. Chiao added that the genome needs to be examined before, during, and after flight. Dr. Longnecker noted that the research will not be done in space; the samples will be collected in space and the research will be done on the ground. One could do both comparative studies as well as longitudinal studies of individuals to look at consequences. For example, we still do not have enough data about cancer rates in astronauts and whether space radiation has altered cancer rates. This research will help move those fields forward.

The collection of all the different "omics" represents a new field called systems biology. It becomes an expanded information technology problem. The planning to enable this platform has the National Institutes of Health (NIH), Intel, and other bioinformatics startup companies in Silicon Valley working with NASA. NASA plans to implement a flight campaign based on this approach.

Dr. Porterfield described the geneLAB science campaign. Experiments will be done based on the collective omics approaches. Samples are brought back to Earth for omics analysis. All of the data goes into a bioinformatics database, which is Open Source data. This creates a pathway to gain observations from spaceflight experiments. NASA will have the opportunity to lead in the area of innovation. A series of NASA Research Announcements (NRAs) will be released to perform the ground research. The research will be spread across many universities and even international researchers. Since this will be Open Source data, considerable competition is expected. CASIS will benefit from the collective biomedical libraries, which will represent potential targets for pharmaceutical partnerships.

In response to a question, Dr. Porterfield indicated that the geneLAB concept is the platform. It can be used with any biological system. In terms of timeline, they are looking at doing some ground-based pilot projects within the next year to develop informatics systems. Some of the existing PIs have agreed to provide samples from the ISS. The first Strategic Development Team meeting will be held around January 2014 to discuss some of the informatics developments. A detailee from the Ames Research Center (ARC) will be the Project Manager. The Division held a workshop last January and has formulated next steps, which are to define an implementation plan for geneLAB, form the Science Team, gain participation from the international partners and other US government agencies, determine how future NRAs will encompass geneLAB, and define the data standards and acquire the data services. The Division has also started looking at a platform for fundamental biology and human research. On the physical sciences side, the Division is looking at creating similar type open sources. They want to develop more community-based research initiatives to create a materials science informatics database. The Division is also driving the engineering side—on what new materials should it focus? The fundamental research program is expected to catalyze CASIS activities and the commercial sector. CASIS will provide input and membership on the teams.

In response to a question, Dr. Porterfield indicated that CASIS is limited to interacting with US companies. The SLPSRA Division within HEOMD interacts with international partners and international space life sciences working groups. Mr. Bejmuk noted a couple of areas where there was interest a number of years ago and queried if anyone revisited these opportunities with those organizations. Dr. Porterfield said that fundamental materials research is still an area of interest within the Division, but he was not sure if CASIS is active in this area. He agreed that it might be of some value. In response to another question, he indicated that CASIS representatives go to trade shows and conduct outreach, but he was not knowledgeable about specifics. The Division does not "advertise" the no-cost aspect of ISS utilization because it is targeting a different type of community. The

SLPSRA Division does hardware development for flight experiments. This hardware can be built in house, under SBIR contracts, or by contractors and subcontractors. Ms. Budden noted that Station is still "pay to play." Despite the covered launch and maintenance costs, the participants still need to develop something worthy of selection.

Dr. Condon noted that in terms of more industry involvement, the Research Subcommittee is all academicians. There is an obvious absence of industry research people. He advocated consideration of people who are in the research area in industry. Ms. Budden agreed and suggested making a recommendation on this. Dr. Longnecker indicated that his Subcommittee would be meeting the following day. From HEO Committee discussions, he agreed that the Subcommittee needs to report to the HEO Committee on CASIS and what it is doing. However, membership on the Subcommittee is not a Subcommittee decision. Dr. Siegel added that membership is still under the NAC; the HEOC, as parent committee, should make the membership recommendation to the NAC.

Status of Commercial Crew and Cargo

Mr. Phil McAlister, Director of the Commercial Spaceflight Development Division, HEOMD at NASA HQ, discussed the status of commercial cargo, CCiCAP, and the CPCs.

SpaceX successfully completed all of its Commercial Orbital Transportation Services (COTS) milestones in May 2012 and has started resupply flight to the ISS. Orbital successfully completed a maiden test flight of its Antares rocket in April 2013 from the Mid-Atlantic Regional Spaceport. This test flight was not in the original Space Act Agreement (SAA). NASA signed a modification to add this feature. Orbital is ready for its final COTS milestone—the COTS demonstration mission to the ISS—currently scheduled for Sep 14-19, 2013. This will be a very challenging mission for Orbital and the ISS team. Orbital is committed to continue with COTS development.

In response to Mr. Cuzzupoli's comment on a recent article that talked about the Antares rocket performance, Mr. McAlister noted that the test flight and the engines met all of the interface requirements, although there was a slight underperformance based on prediction. NASA was thoroughly briefed on that mission, and Orbital learned a lot from it. Mr. McAlister stated that there was nothing that he would characterize as an "anomaly." On the next mission, there will be cargo as well as some secondary payloads. Soon there will be two new, cargo-capable spacecraft to provide a significant level of robustness for cargo transport to the ISS. SpaceX is on the "on-ramp" for the LSP, and Orbital is expected to do the same. COTS has also helped jump-start the nano-sat market. Europe is considering investing in Arianne 6, primarily because of the competition these vehicles pose. In response to a question, Mr. McAlister indicated that SpaceX has a number of non-NASA missions on their manifest.

Mr. McAlister provided an update on the CCP. In December 2012, NASA released three contracts for early-phase, certification-related products. Previously, the companies were focused on milestones that allowed them to accelerate development. Through the CPC contract, the companies are obtaining a lot of feedback and risk mitigation. In response to a question, Mr. McAlister indicated that the NASA certification will include the launch vehicle, but NASA is not certifying it separately. The certification will be for the entire system: spacecraft, launch vehicle, and ground system. However, NASA has insight on the launch vehicle. Space X has a number of interfaces with NASA, and the Program has tried to ensure that the Agency is not asking for the same information a number of times. NASA is trying to share as much data as possible, e.g., with the LSP.

In response to another question related to level of maturity at the end of Phase 1 CPC, Mr. McAlister indicated that at least two of the three companies should be approximately at a CDR-like level of maturity. However, all the contractors do not have to be at the same level to go to the next phase. The first milestone in Phase 2 certification is to establish where they are in their design, e.g., baseline the system. At the end of Phase 2, NASA will certify as "safe enough for NASA personnel for the ISS mission." Mr. McAlister noted that the Program is trying not to use the term "human rating" because it means different things to different people.

Each partner is doing very well in CCiCAP. Boeing has successfully completed 8 of 19 milestones to date. Boeing's launch vehicle is Atlas V Centaur. Both Sierra and Boeing have dual engine Centaur configurations. In response to a question, Mr. McAlister stated that NASA's certification will not apply to missions other than the ISS; although the partners are all probably looking at other missions like a for Hubble Space Telescope (HST) repair mission. Sierra Nevada has completed 5 of 9 of its milestones under CCiCAP. In February, Sierra Nevada completed the Integrated System Safety Analysis Review number 1, which demonstrated that the systems safety analysis of the DreamChaser Space System has been advanced to a preliminary maturity level. In August, Sierra Nevada plans to have a drop test of the engineering test article from a helicopter. SpaceX has completed 6 of 14 CCiCAP milestones. In May, Space X completed the Human Certification Plan Review, which covered plans for certification of the design of the spacecraft, launch vehicle, and ground systems. The purpose of the review was to define the

SpaceX strategy leading to an orbital demonstration flight with crew. The advantage of the SAA is that the partners can move very fast in their development. NASA has negotiated some changes to the schedule, but Mr. McAlister indicated that he expects all the partners to be finished when they say they will.

Simultaneous with the SAAs, the partners are working under their CPCs. The primary objective of CPC is the delivery, technical interchange, and NASA disposition of early-lifecycle certification products. Contract Line Item Number (CLIN) 1, alternate standards, has been a huge advantage for NASA. In many cases, the companies have their own standards that are more efficient. NASA reviews those standards to see if they meet the intent of the NASA requirements; if they do, this saves a lot of time and effort. The companies have been very aggressive in providing the hazards reports (CLIN 2). The partners are defining their verification methods to NASA. In response to a question, Mr. McAlister stated that Failure Modes and Effects Analysis (FMEA) is not a CPC CLIN. He took an action to get back to the HEO Committee regarding FMEA requirements. In response to another question regarding abort cases, he noted that NASA will see what the abort cases are in the next round. They will all have a very stringently evaluated abort scenario. NASA will do the certification. There are several abort-related requirements in the 1130 requirements document. The "human rating" requirements are being applied in both Phase 1 and Phase 2 contracts.

All four contractors met the CPC Phase 1 requirements on all four CLIN deliveries. There were over 30 alternate standards and over 70 hazard reports. NASA has a 90-day window to evaluate and provide feedback to the contractors on whether they are approved or not. Progress over the next month will inform us on our ability to hold to the schedules.

Commercial Crew Transportation Capability (CCtCAP) is the next phase (Phase 2). The draft RFP was released on July 19, 2013. NASA still wants a cost-share partnership, even under this FAR-based contract. It will cover all aspects of final development and certification of a crew transportation system. The final certification package will come to NASA HQ for approval. In response to a question, Mr. McAlister indicated that KSC and JSC have Technical Authorities that are embedded in the CPC program.

Mr. McAlister stated that he carries one primary risk at HQ: prematurely eliminating competition. This is one of the primary risks to satisfying the goals and objectives of the Program—safe, reliable, and cost-effective transportation. Competition supports all three of these simultaneously. Cost effectiveness is a key component, but the partners compete keenly on safety, because they know that element is very important to NASA. The draft RFP says transportation capability as soon as possible, with a goal of 2017.

It was noted that the HEO Committee had previously recommended downselect from three competitors because NASA was not getting the funding it needed to meet the goal. The Committee still felt that the Program will not meet the 2017 goal with three competitors. Mr. McAlister acknowledged that he didn't believe NASA would be able to carry all three through Phase 2; however, two contractors would probably be sufficient to maintain the benefits of competition. A funding level of $822M can maintain competition; however, if NASA receives less than that, the Agency will have some hard decisions. Mr. McAlister expressed his opinion: whatever we get from this program we will be using a long time, and we should not make a short-term decision on something that will have long-term consequences.

Dr. Condon observed that if there is not enough funding to support three competitors, going to two competitors implies that NASA would be able to use all the funding on those two competitors. However, if the competition is downselected to two, NASA may lose some of the dollars. Mr. Kohrs agreed. NASA should have a firm requirement on the date, not just a goal. Mr. Bejmuk stated that in his opinion, the Agency may not be paying enough attention to Russia's situation. NASA has had a wonderful partner in Russia, but they are struggling. Over last two and a half years, they have had a lot of failures, although they haven't had a bad day on Soyuz yet. He posed the question: Are we paying enough attention to the safety threat to NASA people? Mr. McAlister said that this is a good question to pose to Mr. Gerstenmaier as he is more knowledgeable on the subject.

Mr. McAlister discussed the collaboration synopsis. On July 17, 2013, NASA released a synopsis for a potential competitive announcement for the award of multiple SAAs to advance entrepreneurial space-related efforts. There is an inherent benefit to NASA if these companies are successful, and NASA has policy documents that say they should support commercial development of space. These SAAs would involve no exchange of funds. They would enable NASA to provide technical expertise, lessons learned, and data. Industry would bear the cost of its participation. These agreements would focus on the development of integrated space capabilities, not individual technologies or subsystem development efforts. On the CCP, the companies have requested over 1000 documents from NASA to help their development process. NASA also has a lot of technical interchange meetings that helps the partners. Blue Origin requested an unfunded extension to their SAA to keep collaboration with NASA going. NASA has released the collaboration synopsis, but has not committed to making awards. These

agreements if executed would not preclude companies from entering into any other partnership with NASA. It would be a mechanism for NASA to gain insight into what the commercial sector is doing. Responses to the synopsis are due August 7, 2013. This input will allow NASA to gauge interest and determine whether the Agency will go to the next step.

Overall, everything on commercial crew is going well, but there are some significant challenges, primarily the budget. Since none of the partners are at the CDR level yet, there are also some technical challenges.

Via telecom, Mr. Richard Malow commented regarding the budget. This year, NASA has seen some encouraging numbers from Congress. The Continuing Resolution (CR) will be at the current rate or lower. If the CCP has to move along at the $500M-$550M rate, what would be the effect? Mr. McAlister responded that it would slow the Program down, and he didn't know what decision NASA would make if the budget was at the $500M level. It would be up to NASA to decide what would be in the best interest of the Program—downselect, slip schedule, or some other approach. NASA wants to maintain competition, so it would have to trade the benefit versus what else it would be getting. In response to a question regarding the status of the 2013 budget number, Mr. McAlister indicated that the CCP was appropriated for $525M; however, that amount was "pre-sequestration." In general, sequestration equals a 7 percent cut across the Agency. NASA has some small flexibility to move some funds around within its operating plan. The 2013 number will be somewhere between $488M and $525M.

Joint Session with NAC Technology Committee

Mr. Kohrs stated that one reason he requested a joint session was the interest spurred at the last meeting regarding the ARM. Dr. Matt Mountain, Vice-Chair of the Technology and Innovation (T&I) Committee indicated that his Committee wanted to understand how the ARM mission maps to the technology plan. Dr. William Ballhaus, Chair of the T&I Committee outlined (via telecom) what the T&I Committee interest was in this presentation: (1) to understand the rationale behind the mission; and (2) to understand what the technology "long-poles" are and what the "pull" would be on the technology program. Mr. Kohrs stated that his understanding was that the technology long-pole is the solar electric power technology. The HEO Committee and the T&I Committee members introduced themselves before the briefing started.

Technology Briefing

Dr. James Reuter, Deputy Associate Administrator for Programs for the STMD at NASA HQ, provided an overview of the STMD, what the STMD portion of the ATM is, and how the STMD supports the overall plans for NASA's horizon target—Mars surface.

STMD wants to enable a new class of missions, and there are critical capabilities that need to be developed to enable future human and robotic missions. STMD wants to deliver innovative solutions that dramatically improve technologies and affordability for NASA missions. In addition STMD wants to contribute to creating new marketplaces and spurring innovation. The challenges for deep space exploration have not changed in the past 20 to 30 years. NASA has been involved many times in studying what would be required for deep space exploration. In the area of communications, higher bandwidth is needed; in terms of ECLSS, the current capabilities on Station will not be practical for deep space missions. Reasonable solutions to radiation problems are needed. The propulsion technology roadmap shows technology hurdles, and NASA has made very little progress in terms of high-powered solar electric propulsion or a nuclear propulsion capability.

What are the trends today? They include the new paradigm of small spacecraft (e.g., cubesats), robotics that interact with and support people (e.g., Robonot-2 on ISS), additive manufacturing and transition to composites (e.g., the SLS future upper stage), EDL, propulsion, and communications.

STMD has several key principles that guide strategy. The Space Technology programs follow the NASA Strategic Plan and the NASA Space Technology Roadmap. STMD has completed the roadmaps and has an NRC report that has prioritized them. STMD is using the NRC roadmap to set priorities and justify investments for the future. STMD invests in a comprehensive portfolio, spread across the entire Technology Readiness Level (TRL) spectrum. In response to a question regarding the duration of a typical project, Dr. Reuther said that a low-TRL project can be a nine-month study. A high-TRL project can stretch over seven years. NASA uses a competition-based model to select a substantial portion of the portfolio. At the lower TRLs, almost all the projects are competed; at a higher TRL, a project may be directed to where NASA has a workforce attuned to that job. NASA is no longer doing open-ended research projects. All projects have fixed start dates, fixed end dates, a set of milestones, and a budget. If the technology is not progressing, STMD will stop the project and invest elsewhere. The philosophy is "infuse rapidly or fail fast." The goal is to get NASA back at the cutting edge of technology. The portfolio-based investment strategy can play a substantial role in putting NASA back at the cutting edge and put the Nation back onto a technology-based economy. Mr. Bejmuk

asked if the guiding principles include collaboration with industry. Dr. Reuther agreed that collaboration with industry should probably be listed as one of the principles; however, it is embedded in everything STMD does.

Nine programs comprise the Space Technology portfolio. The Technology Demonstration Missions (TDMs) include co-investment or joint-investment. Often, the same technology is needed by other government agencies or the commercial sector. In TDMs, there must be a contribution from another entity. The collaboration is built into the solicitation. In the Game-Changing arena, many projects tend to be partnered with other government agencies. Exploration Technology Development (ETD) is focused on human exploration initiatives. Low-TRL developments include NASA Innovative Concepts (NIAC), the Center Innovation Fund (a grass-roots development at the Centers to bring about a culture of innovation), and Space Technology Research Grants (grants to universities that are working on space technologies applicable to NASA). For developing new marketplaces, STMD has Centennial Challenges, Small Business Innovative Research (SBIR)/Small Business Technology Transfer (STTR), and the Flight Opportunities Program. The SBIR/STTR project has a significant budget within NASA technology. Centennial Challenges motivates new participants into the aerospace domain. The Flight Opportunities Program is using suborbital platforms for an integrated marketplace. Cryogenic Propellant Storage and Transfer (CPST) is a $400M, seven-year lifecycle demonstration project. It has been one of the key capabilities needed for human exploration. All of the "big nine" projects are the cost drivers in the budget. They are high profile and receive a lot of press. The other large element of the budget is the workforce. Several flight demonstrations have already occurred, such as Robonot in 2012-2014. The Solar Electric Propulsion (SEP) demo and cryopropellant demo are further out in the timeline.

Dr. Reuther discussed the Asteroid Initiative. NASA is planning a first-ever mission to capture and redirect an asteroid to Earth-Moon space. NASA will also lead a broad effort to find all asteroid threats to human populations and know what to do about them—a "Grand Challenge." These two missions are referred to as "the Asteroid Initiative." The ARM is composed of three elements: detection and characterization of candidate asteroids (filling needs for both the Grand Challenge and ARM), asteroid capture and redirect, and a human mission. For the ARM, Space Technology will focus on high-powered SEP. This would be used for asteroid rendezvous and redirection, not the human mission. However, SEP would enable deep space exploration. SEP is being used today for satellite station-keeping and transfer orbits, but none of these are considered "high-power." The maximum power demonstrated today has been 15kW to 4.5kW per thruster. Mass to LEO assumes SEP capability of 300kW. Any deep space mission out of cis-lunar space in terms of months would be hugely leveraged by a human-class SEP system. The STMD goal is to demonstrate extensive SEP technology at 30-50kW power that could be extended to higher powers.

SEP is the primary propulsion for the robotic asteroid rendezvous and redirection mission. This mission could not be done without it. In response to a question regarding the budget request for the asteroid mission, Dr. Reuther stated that NASA has been considering the costs and what the mission would look like. The mission feasibility review is baselining a point of departure for the mission: what it would cost, what capability it would provide, etc. Dr. Reuther indicated that it would be premature for him to discuss any outcomes from the mission feasibility study at this time. However, a precursor study estimated $2.5B for the robotic mission. It now appears that the cost would be about half that, but this is very preliminary. The range will be somewhere between $1B and $1.5B.

The Grand Challenge is interested in enhancing the near-Earth observation campaigns and interacting with them. The goal would be to develop a mitigation strategy in the event there is an asteroid that poses a threat. Diverse stakeholder engagement would be considered.

Dr. Reuther showed the alignment strategy timeline. With the enhanced capabilities that should be in place, there should be a final target selection by the 2016 timeframe. A SEP-powered robotic mission could be launched in the late 2017-2018 timeframe. That would be followed with an Orion mission, probably EM-3 rather than EM-2. By the EM-3 and EM-4 timeframe, the Agency will need some additional objectives. Based on current projections, NASA does not have the budget to do any other mission in the 2022-2023 timeframe. The ARM happens in the right timeframe and provides an affordable target when NASA only has Orion and SLS as exploration assets.

Dr. Reuther discussed the Space Technology role in the Agency asteroid strategy. Early-stage programs will foster innovation regarding asteroid detection and mitigation/defense, asteroid selection for the ARM, and asteroid proximity operations. Game Changing will complete high power SEP technology development as a precursor to doing an SEP demonstration of 30 to 50kW-class solar arrays. In FY2014, ARM received additional funding that will cover flight hardware solar array procurements and electric propulsion thruster engineering development units. Primary Centers involved are GRC and the Jet Propulsion Laboratory (JPL). These are the Centers that have expertise and on-going work in SEP. In terms of square footage, the largest geocom satellites (advanced geocoms) can be sized up to 25kW per wing. The arrays can be up to 100 feet long and six feet wide. They

are solid panel, fold-out arrays. What is different about the NASA demonstration is the packaging—these arrays will store in one-third the volume of the current arrays and are one-half the mass, which is non-trivial. Geocom is very interested in the larger power levels.

In response to a question, Dr. Reuther noted that the asteroids that NASA is considering as potential targets for the ARM are near-Earth, with orbits similar to Earth. The delta-v to Earth must be relatively small—2 k/sec or less. These are asteroids that are observable because they fly by more than once.

There are two vendors for high-powered solar arrays: Deployable Space Systems (DSS) and ATK. The ATK array technology was baselined on the Mars Phoenix mission. It has been demonstrated on many occasions, but the size is new. It is much larger than anything in the past. The rollout arrays can be done by Z-folding or with a blanket technology. In terms of the thruster units, the real breakthrough in Hall thruster technology was in magnetic shielding. Now we have analytical models that will predict the right shade to minimize metallic erosion. The next generation of Hall thrusters should have almost unlimited capability. In terms of tanks, new Xenon tanks are needed to carry the Xenon propellant for the mission.

Many other government agencies, such as NRL and the Defense Advanced Research Projects Agency (DARPA), are interested in SEP and the demonstrations. SEP is a great operation for orbital debris removal. There are many science mission applications that can leverage SEP. Satellite servicing is another application.

To date, the Advanced Extremely High Frequency (AEHF) satellites have the largest SEP. It is in the 16kW class and can fire two thrusters at a time. The ARM will have 50kW with Hall thrusters. Far-term exploration missions (in the 2030s) will have 300kW electric power.

There is synergy between STMD and HEOMD. STMD does not do systems-level development; it transfers technology projects at TRL 6. The AES Program is the place within HEOMD where the technology systems work is infused. STMD also works with the HEOMD HRP for radiation mitigation.

The ARM will help achieve SEP for cargo/logistics, deep space Guidance/Navigation/Control (GNC), crew operations beyond LEO (Orion), crew return from beyond LEO–HS entry (Orion), and heavy lift to beyond LEO (SLS). The first two are STMD/ETD and HEOMD/AES investments; the latter three are joint HEOMD/ESD/AES investments. Dr. Reuther showed the infusion of Game Changing and TDM technologies in ETD.

In response to a comment from Mr. Kohrs, Dr. Reuther agreed that for SEP at 40-50 kW and six metric tons Xenon, the mission could go on an Atlas launch vehicle and spiral out. However, for 12 metric tons Xenon without the spiral out, the mission would need to go on SLS. With SEP and a range of launch vehicles, there is not the necessity for a specific launch window for a NEO. The propulsion can be slower and over a longer trajectory.

Committee Discussion and Recommendations

Dr. Kohrs canvassed the Committee for any findings or recommendations. Dr. Chiao noted that there are conflicting desires, both internal and external to the Agency, of where NASA should be going. This is having a negative effect on the process. Without a clear direction and agreement, how can budgets be planned and programs formulated? There needs to be more agreement among the parties. The Administration and the Congress appear to have different goals and destinations.

Mr. Bejmuk observed that even within NASA it is confusing. If Mars is the ultimate destination, everything else should be supportive of that and a “stepping stone” to that objective. That does not come through in the presentations. Dr. Condon agreed with Mr. Bejmuk and noted that in looking at NASA’s response to HEO Committee recommendations from the last meeting, it is not reflected anywhere. The House Committee took an action to zero out the funds for the asteroid mission. This action is, in part, responsible for an absence of clear direction. The House Committee does not see the asteroid mission as a clear stepping stone to Mars and doesn’t support it. Mr. Bob Sieck added that the ARM does not appear to be connected to any budget line for Mars. In fact, there is no “Mars line” in NASA’s budget. Dr. Condon commented that NASA’s answer confirms that the President has set Mars as an ultimate destination and that is where the Agency will go, but one cannot get any strong sense that anyone at NASA is serious about it. For example, there is nothing in the budget for lunar landers or habitats. One of the frustrations is that the HEO Committee has conveyed this concern in the past, but in spite of NASA’s responses, it doesn’t appear to “stick.” Ms. Budden suggested that perhaps the HEO Committee should be more specific in its recommendation; for example, request that NASA’s larger goal be articulated on its website and show accomplishments toward that end. Mr. Kohrs acknowledged that any destination is better than no destination, but within NASA, there are some that are not supportive of the asteroid mission. NASA

should "speak with one voice," but it is difficult to get everyone behind a destination when they don't know what their budgets will be.

Dr. Longnecker observed that he did not hear anyone say NASA is not going to Mars. In fact, the technology presentation did show a "path to Mars." Dr. Condon added that every project may have application to Mars or lead to that end objective, but it is not being effectively communicated outside of NASA HQ. Even on the Hill, there is a lack of understanding that everything NASA is doing is a stepping stone to Mars. It has never been articulated or laid out that way.

Mr. Kohrs noted that NASA doesn't have to do the asteroid mission to go to Mars; however, going to an asteroid helps promote Orion and understanding the radiation environment. The main gain from the asteroid mission is SEP. NASA should expedite the process or eliminate the hurdles that will allow the Agency to communicate effectively about the mission.

With regard to the commercial piece, Mr. Malow commented that the Senate appropriations language gave a substantial increase to the program. Mr. Kohrs indicated that at the last NAC meeting, the HEO Committee's prior recommendation to downselect from three contractors was tabled. Mr. Sieck suggested recommending that NASA put together a schedule (with real milestones) on how they achieve the 2017 target. The HEO Committee understands NASA's desire to prolong competition. However, the U.S. is currently dependent on a sole provider—Russia—for crew transportation. If the budget reality is going to prolong that dependence, that is a threat. Mr. Malow added that the trade is between schedule and competition. He indicated that he would lean more toward schedule as the higher priority. Mr. Kohrs suggested changing the "goal" of 2017 to a requirement. Mr. McAlister has told the Committee that because the budget had been reduced, the schedule is moving out. As long as that continues, the schedule will keep moving out.

Mr. Malow observed that the Senate language is interesting. There must be some decision for the ISS to continue beyond 2020; otherwise, NASA is spending $2.5B for three years of activity, which doesn't make sense. All things being equal, if the Program has enough funding to continue at the $700M to $800M range, schedule should be more important than competition. Mr. Bejmuk noted that as long as NASA only has a "goal" and does not have a specific target, they cannot really defend the budget. Considering what is happening in Russia, he expressed concern about safety the longer NASA continues with Russia as the sole transportation provider for crew. Dr. Chiao shared his concern regarding Russia's infrastructure. There may be some erosion of infrastructure that might be making things more risky. However, any new vehicle is going to be risky as well. In any event, NASA needs to develop new vehicles and get the transportation capability back. Mr. Kohrs agreed that the schedule should be emphasized, but not necessarily for safety reasons. The primary reason is to get U.S. capability for the dollars being spent. Mr. Cuzzupoli recommended that NASA take action to make the CTS happen by 2017, and let NASA decide whether that takes two or three contractors. To adequately protect Station, there should be a second transportation path.

Mr. Kohrs proposed working on the recommendation that was brought forward at the last meeting. Mr. Cuzzupoli suggested adding words about having a firm need date for commercial capability.

Going back to the first Committee discussion on conflicting priorities within NASA leadership, Mr. Kohrs observed that if NASA is going to work on the asteroid mission, everyone should get on board with that. The "Grand Challenge" may be creating a problem across the Agency. Mr. Jim Odom added that there was a lot of discussion on the Hill about asteroid threats. If NASA is going to go with an asteroid mission, one of the key objectives should be to learn how to redirect one. He felt that relegating that to a secondary or tertiary requirement would be a mistake. He agreed the asteroid mission should be a stepping stone to Mars, but if ARM is going to be done, there should be some benefit to Earth as well. Dr. Condon observed that what to do with an asteroid mission appears to be evolving. The "Grand Challenge" aspect is new. If NASA is not clear on why it is pursuing the Asteroid Initiative, it will have the appearance of another "hobby-shop" activity without a purpose.

Dr. Longnecker queried whether it would be valuable to make a recommendation encouraging communication about "first steps towards Mars," for example, encourage each mission directorate to demonstrate how it is contributing to this long-term mission. Mr. Odom questioned how well the program is supported outside of the new technology organization. Dr. Condon added that everything that NASA is doing that contributes toward a human mission to Mars should be easy to find on the NASA website. Currently, what NASA is trying to do and how the Agency is going about it is not coherently articulated. What is the goal? What is the mission? What is the direction? The asteroid mission should be part of that. Mr. Kohrs suggested putting together an observation and recommendation on this.

One of the things discussed regarding Station was the utility of ISS beyond 2020. As a matter of policy, US involvement ends at 2020. If ISS is going to support a future Mars mission, there is a need for Station to go beyond 2020, and there is a need for an

amendment to the policy to state the intent to go beyond 2020. Based on benefits the HEO Committee sees coming out of Station and its potential to continue to provide benefits, not the least of which is a human mission to Mars, NASA should extend utility beyond 2020.

Russia has completed its assessment for continuing its hardware through 2020. They are about one-third of the way through their assessment on 2028. NASA has not yet finished with its assessment through 2020. When that assessment is complete, the Agency will make a decision on the policy. According to JSC's schedule, the NASA assessment should be complete by October 30, 2013. Mr. Kohrs suggested that it might be advisable to wait until NASA is finished with its assessment and reports out before making any recommendation regarding 2028. He asked that an update on the results of the assessment on extending the Station to 2020 and beyond be added as an agenda item to next meeting.

Mr. Odom suggested deferring his proposed recommendation on the asteroid mission.

Mr. Bejmuk suggested talking to Mr. Gerstenmaier about visiting the field Centers and holding "all hands" meetings there. Mr. Kohrs noted that there was a recommendation concerning morale that was put forward by the Operations Committee a couple of meetings ago.

With regard to SLS, a question was raised about recovering the boosters for examination. A one-time attempt may not be that expensive and it may provide very useful data. It was noted that NASA could decide to do this after the fact.

Mr. Kohrs stated that the HEO Committee is satisfied with what the ESD team is doing, but the Committee will continue to monitor. He noted that the Aerospace Safety Advisory Panel (ASAP) is also looking at ESD systems integration as well as system-level hazard analysis.

Mr. Cuzzupoli suggested saying something positive about ESD with regard to improvement on the integration aspect. They appear to be managing the program schedule and cost, although he was somewhat disappointed on the results on where they are in the program. They are going to go through a major redesign on EM-2, and the choices are: take weight out of Orion or wait until block 2 and make the changes at that time, after the results from EM-1. The other fix is to extend the hydrogen tank for additional propellant to get better performance. Mr. Cuzzupoli noted that the Committee also heard about the possibility of a new second stage. They discussed the weight that needed to be reduced (2000 to 4000 lbs) and the margin that is needed. Mr. Cuzzupoli observed that there are some issues that are near-term and some decisions that need to be made, such as on EM-2. Mr. Gerstenmaier alluded to possibly having to move the schedule. The Committee needs to get an update on this topic on a quarterly basis.

Mr. Odom noted that due to the budget, ESD is focused on EM-1; when they get through with that, they will start worrying about EM-2. The budget they anticipate getting will push EM-2 even further out. Mr. Gerstenmaier has already recognized that he may have to move EM-2 out because of budget. The project managers are concerned, but they cannot affect it much.

Mr. Bejmuk suggested that the Committee consider the following recommendation: Don't take weight out of Orion beyond what it takes to solve the parachute landing loads (e.g., to improve ascent performance). Mr. Kohrs felt that this recommendation might be getting too deeply into the design details. Ms. Budden proposed augmenting the prior recommendation to add internal and external communications, such as updating the website.

Mr. Longnecker indicated that he would take the HEO Committee comments regarding expanding the Research Subcommittee membership back to his group. Ms. Budden suggested that the HEO Committee formally recommend that the Research Subcommittee membership be extended to include industry research representatives. Given the Subcommittee's relationship with CASIS, it needs input from people who lead research initiatives in the private sector. Mr. Longnecker offered to draft something for Mr. Kohrs to present at the NAC meeting.

The HEO Committee decided to put forth three recommendations and one finding. In addition, the Committee prepared a reply (and additional recommendation) to NASA's response to one of the HEO Committee prior recommendations.

Proposed recommendation on elevating the priority of commercial crew development: NASA elevate the priority of the commercial crew development and vigorously protect its funding, *and establish a schedule with traceable milestones and target date for first crewed mission in 2017*. These NASA actions are needed to avoid undesired growth in the commercial crew

development time and risky increased reliance on a single provider, Soyuz. If required funding is not provided, the recommended action is to protect the 2017 schedule.

Major reason for recommendation: Rapid establishment of U.S. domestic crew transportation to ISS is critically important to the sustainability of the U.S. human space program. The NAC HEO Committee observed a very significant shortfall in Commercial Crew Program funding over the past three years, typically on the order of 40 percent less than requested. During this funding shortfall period, NASA has been funding three potential providers and maintaining the 2017 schedule. The NAC HEO Committee's opinion is that continued reduction in commercial crew budget, funding the three providers, and maintaining 2017 schedule is not possible

Consequence of No Action: Increased risk due to reliance on only one supplier (Soyuz) for transportation of U.S. astronauts to the ISS.

NAC HEO Committee Finding: The NAC HEO Committee was briefed on the Exploration Systems Directorate status and schedule. We commend the Systems Engineering and Integration Management team's progress in the schedule, cost, and management of the Integrated Task. Future reviews on this subject by the NAC HEO Committee should continue. Major program issues that are currently being evaluated by the Integration Team should be updated and reviewed by the HEO Committee.

Proposed Recommendation on Research Subcommittee: NASA should add commercial expertise to the already impressive membership of the Research Subcommittee of the HEO Committee. Specifically, the committee should receive input from research, development, and commercialization leadership in one or more of the relevant industries (e.g., pharmaceutical, biologicals, materials science, etc.) that have experience in applied research.

Major Reasons for Proposing the Recommendation: The current committee is populated by an impressive cadre of research leader from academia, but the commercial opportunities for research in microgravity are equally important, as evidenced by several projects that have been achieved to date. Further, such input would provide a valuable link to the activities of CASIS, which has relationships with the SLPS program.

Consequences of No Action: Committee deliberations will reflect only the viewpoints and perspectives of academia, and thus will not provide NASA with the broadest possible guidance from an important contributor to the research community.

HEO Committee Reply to NASA HQ Response to NAC Recommendation to demonstrate and articulate the justification and strategy for NASA's new Asteroid Initiative

Recommendation: During the last NAC meeting, the HEO Committee recommended that NASA clearly demonstrate and articulate a strategy for the Agency's new Asteroid Initiative and highlight associated benefits to the public. NASA responded by sending the HEO Committee a summary of the Asteroid Initiative. The HEO Committee acknowledges and appreciates the HQ response to our recommendation. We want to extend the recommendation to add that NASA work to reflect current priorities and planning for the Asteroid Initiative, among other waypoint steps, to the ultimate Mars Mission via internal and external communications.

NASA should immediately update the NASA Website to reflect current planning (including the necessary steps to progress from current capabilities to those needed for successful human Mars exploration), priorities, technical plans, and accomplishments, such as those summarized by the STMD.

Major reason for proposing recommendation: The current NASA website lacks definition of an articulated step-by-step plan and lacks a summery of plans, recent successes, and accomplishments that demonstrate how NASA is moving forward towards future human exploration of space.

Lack of information for NASA employees and the public, on NASA websites and other communications, leads to the perception that NASA lacks a well-developed, Agency-wide, and focused plan for future missions.

Consequence of No Action on the proposed recommendation: As we stated before, in the absence of a clearly demonstrated and articulated justification, the new Asteroid Initiative might miss external interest and support, leading to loss of public and Congressional support. NASA risks losing U.S. and international confidence in its place as the leader in human space exploration.

The next NAC meeting is at KSC in November. Mr. Kohrs suggested that the HEO Committee meet at the same location the week before.

There were no public comments, and the meeting was adjourned.

NASA ADVISORY COUNCIL

Human Exploration and Operations Committee
MEETING

NASA Headquarters
PRC, Room 9H40
Washington, DC 20546-0001

Monday, July 29, 2013

Agenda

Committee Public Meeting

10:00 – 10:03 am	Opening Remarks	Mr. Richard Kohrs & Dr. Bette Siegel Chair & Executive Secretary NAC HEO Committee
10:03 – 11:00 am	Status of Human Exploration and Operations	Mr. William Gerstenmaier Associate Administrator
11:00 – 12:00 pm	Status of Exploration Systems Development	Mr. Daniel Dumbacher Deputy Associate Administrator for Exploration Systems & Development, NASA HQ
12:00-1:00 pm	**LUNCH**	
1:00 –2:00 pm	Status of International Space Station	Mr. Sam Scimemi Director, International Space Station, HEOMD, NASA HQ
2:00 pm	**ADJOURN**	

Tuesday, July 30, 2013

Committee Public Meeting

9:00 – 9:03 am	Opening Remarks	Mr. Richard Kohrs & Dr. Bette Siegel Chair & Executive Secretary NAC HEO Committee
9:03 -10:00 am	Status of CASIS and Research Subcommittee	Dr. D. Marshall Porterfield Director, Space Life and Physical Sciences Research and Applications Division, HEOMD, NASA HQ
10:00 – 11:00 am	Status of Commercial Crew and Cargo	Mr. Phil McAlister Director, Commercial Spaceflight Development Division, HEOMD, NASA HQ

11:00– 12:00 pm	***Joint Session with NAC Technology Committee***	
	Technology Briefing	Dr. James Reuter Deputy Associate Administrator for Programs Space Technology Mission Directorate, NASA HQ
12:00-1:30 pm	**LUNCH**	
1:30 – 3:25 pm	Committee Discussion and Deliberation	
3:25 - 3:30 pm	Public Comments & Input	
3:30 pm	**ADJOURN**	

Human Exploration and Operations Committee Membership
July 2013

Mr. Richard Kohrs *Chair*	Former Deputy Director of the NASA Space Shuttle Program and Director of Space Station Freedom
Mr. Bohdan I. Bejmuk Co-Chair	Aerospace Consultant, former Space Shuttle Orbiter Program Director, Boeing
Dr. Bette Siegel Executive Secretary	NASA Headquarters
Ms. Shannon Bartell	Former Kennedy Space Center Safety & Mission Assurance Director
Ms. Nancy Ann Budden	Director for Special Operations Technology, Office of the Secretary of Defense
Dr. Leroy Chiao	Former NASA Astronaut and International Space Station Commander
Dr. Stephen "Pat" Condon	Aerospace Consultant, former Commander of the Ogden Air Logistics Center, The Arnold Engineering Development Center, and the Air Force Armament Laboratory
Mr. Joseph Cuzzupoli	Former Assistant Apollo Program Manager, Rockwell, and manager of the Space Shuttle Orbiter Project
Mr. Tommy Holloway	Former Space Shuttle and International Space Station Program Manager
Dr. David E. Longnecker	Director, Health Care Affairs, Association of American Medical Colleges (AAMC), member of the National Academy of Sciences Institute of Medicine (IOM)
Mr. Richard Malow	Distinguished Advisory at the Association of University for Research in Astronomy (AURA)
Mr. James Odom	Former NASA Associate Administrator for Space Station Freedom
Mr. Bob Sieck	Former Space Shuttle Launch Director

Human Exploration and Operations Committee
NASA Headquarters, Washington, DC

July 29-30, 2013

MEETING ATTENDEES

Committee Members:

Kohrs, Richard, *Chair*
Bejmuk, Bohdan, *Co-Chair*
Siegel, Bette, *Executive Secretary*
Chiao, Leroy
Budden, Nancy Ann
Condon, Stephen "Pat"
Cuzzupoli, Joseph
Longnecker, David
Malow, Richard (telecom)
Odom, James
Sieck, Bob

Technology and Innovation Committee Members Attending Joint Session:

Ballhaus, William, *Chair* (attending via telecom)
Green, Michael, *Executive Secretary*
Antonsson, Erik
Correll, Randall
Eichhorst, Gordon
Mountain, Matt
Newman, Dava
Neyland, David
Weber, Mary Ellen
Ying, Susan

NASA Attendees:

Adde, Barbara
Anderson, Molly
Baker, Robert
Banes, Robert
Bolden, Charles
Broadwell, Marguerite
Buck, Josh
Chang, Susan
Clarke, Steve
Dumbacher, Dan
Eastman, Randy
Edwards, Ashley
Frankel, David
Frankel, Paula
Gallagher, Kathleen
Gazarik, Michael
Gerstenmaier, Bill
Graybill, Michael
Guidi, Cristina
Hill, Bill
Hinkle, John
Ip, Angela
Irving, Rick
Kamm, Shari
Kanumura, Gautam
Klumpar, David
Kregel, Jonathan
Letchworth, Janet
Lillard, Randy
Madham, Alex
Maxwell, Theresa

Other Attendees:

Cohen, Ben	Commercial Spaceflight Federation
Dembling, Anyan	[no affiliation listed]
DiBiasi, Lamont	SWRI
Hawes, Mike	LMCO
Holmes, C.P.	NAC/ITIC
Leone, Dan	Space News
Limperts, John	Aerojet
Marsh, Celinda	OMB
O'Connor, Bryan	ASAP
Richardson, Larry	ULA
Squyres, Steve	NAC
Tabache, Micheline	ESA
Terrell, Kim	KIMS

WebEx Attendees:

Adkins, Bill
Angleman, Alan
Atkinson, Loretta
Baxton, Michael
Belle, Carolyn
Bransome, Darrell
Campbell, Paul
Cates, Grant
Clark, Stephen
Davis, Stephan
Dean, James
Demetrie, Cornel
deSeldeng, Peter B.
Graham, Sandra

McAlister, Phil
McConnoughey, Paul
McKay, Meredith
Miller, James
Payne, Stefanie
Pearce, Bob
Peck, Mason
Pelfrey, Joseph
Perrotto, Trent
Porterfield, D. Marshall
Rasco, Dorothy
Robinson, Shawanda
Sadhunani, Komal
Saiyed, Naseem
Scimemi, Sam
Sofge, Albert
Smith Greg
Sparrow, Richard
Steitz, Dave
Stilson, Stephanie
Suzuki, Nantel
Van Sant, Tim
Younes, Bodri

Hawes, Mike
Hendrickson, Dan
Hershom, Steven
Kaufman, Bradford
Keysner, Alan
Kronmiller, Ted
Kyatemik, Kathryn
Landes, Rob
Lapidus, Mike
Luper, Alton
Moloney, Michael
Nazario, Margaret
Nguyen, Johnny
Oatens, Robyn
Palenkas, Michael
Pietrzyk, Robert
Simmons, Nigel
Smith, Marcia
Smith, Mike
Stanton, Ed
Sykes, Mark
Watson, Joseph
Wilson, David A.
Zimmerman, James
[no last name given], Bob
[no last name given], Dale
[no last name given], David
[no last name given], D.D.
[no last name given], Gabriel
[no last name given], Irene
[no last name given], Jared
[no last name given], Pete
[no last name given], Ryan

Human Exploration and Operations Committee
NASA Headquarters, Washington, DC

July 29-30, 2013

LIST OF PRESENTATION MATERIAL

1) Status of Human Exploration and Operations Mission Directorate (HEO) [Gerstenmaier]
2) Status of Exploration Systems Development [Dumbacher]
3) International Space Station Program Status [Scimemi]
4) International Space Station Payload Integration [Scimemi]
5) NASA and the Legacy of the International Space Station [Scimemi]
6) Research Aboard the International Space Station [Porterfield]
7) Space Technology Mission Directorate Briefing [Reuther]